Applied Occupational and Environmental Hygiene
Volume 16(5): 502–505, 2001
1047-322X/01 $12.00 + .00

**Construction**

# Lead Exposure During Hot Cutting of Stripped Steel

*Paul Becker, Column Editor*

Reported by Simone Brumis, Peter Scholz, and Barbara Materna

The Occupational Safety and Health Administration (OSHA) Welding Safety Orders for hot work on painted steel structures require that lead-based paint be stripped back "a sufficient distance from the area to be heated to ensure that the temperature of the unstripped metal will not be appreciably raised." For enclosed spaces, this distance must be at least four inches from the weld or cut line, or workers must wear supplied-air respirators.(1) The somewhat stricter Cal/OSHA Construction Safety Order requires that all surfaces covered with toxic preservatives be stripped at least four inches from the weld or cut line (no mention of enclosed spaces), or workers must wear supplied-air respirators.(2)

The California Department of Health Services (DHS) Occupational Lead Poisoning Prevention Program received anecdotal evidence that ironworkers performing hot work on previously stripped steel may encounter high airborne lead levels. These exposures may be caused by a failure to meet the four-inch-minimum OSHA requirement, or by hot work so intense that excessive lead fumes are created even when the paint is stripped back. The lead source may be residual paint on the surface or possibly lead in the base steel. To investigate this issue, DHS industrial hygienists conducted air sampling of an ironworker's exposure to lead fumes during two days of hot cutting 3/4-inch steel for a major seismic retrofit job on a bridge. The general contractor had purportedly stripped the lead-based coating back four inches from both sides of the cut lines prior to cutting.

## Background

Very few task-based exposure assessments of ironworkers engaged in the hot cutting of painted steel exist. A 1988 Canadian study of a demolition project that included the oxy-acetylene torching of an old water purification system demonstrated that sandblasting a six- to eight-inch strip from the painted metal prior to cutting significantly reduced breathing zone air levels from a mean of 21,330 $\mu$g/M$^3$ to mean values of 1300 $\mu$g/M$^3$ and 1100 $\mu$g/m$^3$.(3) A recent task-based exposure assessment evaluated oxy-acetylene torch cutting on stripped steel associated with a bridge renovation project and with an elevator demolition project. The study explored the practical technical and management problems of completing paint removal prior to torch cutting.(4)

**FIGURE 1**
Ironworker cutting painted steel forms on bridge.

## Methods

In November 1998, DHS industrial hygienists conducted two consecutive days of task-based personal exposure monitoring of an ironworker cutting 3/4-inch steel on the western span of the San Francisco-Oakland Bay Bridge. The Bay Bridge was constructed in 1936, and the existing paint is known to contain high levels (approximately 20–40%) of lead.(5)

The work consisted of hot cutting 40 one-inch by 24-inch segments from existing painted 3/4-inch steel forms (Figure 1). These steel forms were being trimmed to accommodate installation of additional outer steel braces for earthquake retrofit. The ironworker used a Lincoln Arc Ironworker CIV-25 with carbon arc electrode rods (Copperclad Arcair) on the first day, and an oxygen/propane torch on the second day. Actual hot-cutting time consisted of 166 minutes on day one, and 154 minutes on day two. For the eight-hour time-weighted average (TWA) calculation, zero exposure was assumed for the remainder of each shift.

The paint had been stripped back from the cut line by the general contractor previously using open sandblasting. A tape measure was used to record the actual distance that the paint had been stripped back from each of 12 cut lines, on both front and back surfaces. Direct readings of lead levels on both stripped and unstripped steel were taken using a Niton XL-309 X-ray fluorescence (XRF) analyzer. A bulk sample of the paint was collected and analyzed. Personal samples in the operator breathing zone inside the welding helmet were taken on both days. On day two, separate filter samples were collected for (1) exposure when cutting on stripped steel (91 minutes) and (2) exposure when making five corner cuts on steel that had not been stripped of paint (63 minutes). A laboratory accredited by the National Lead Laboratory Accreditation Program performed the analyses, using Environmental Protection Agency method #SW-846 for analysis of metals in paint chip samples, and NIOSH method #7300 for analysis of airborne lead particulates.

## Results

*Content of Lead and Other Metals in the Paint*

Laboratory analysis of the bulk paint chip showed 4.2 percent lead by weight in the bridge paint at this location. This result is much lower than the 20 to 40 percent levels of lead typically found in bulk samples taken on San Francisco Bay Area bridges of this era. Analysis for three other metals showed 1900 ppm (0.19%) chromium, <50 ppm arsenic, and <2 ppm cadmium.

At the worksite, XRF analyzer readings confirmed a positive reading for lead (mean of 52 mg/cm$^2$ for 28 readings of unstripped areas). The depth indicator on the XRF demonstrated that the lead was concentrated in the deepest, bright-orange layers. The Niton XRF Spectraview L-shell spectrum was analyzed to determine whether other elements were present in the paint. The model used gave qualitative, but not quantitative, results for metals other than lead. The spectrum proved that iron and zinc were both present above the detectable limit (DL) of 500 ppm. Furthermore, it indicated that the following elements that are often found in paint were not present above the DL of 500 ppm: arsenic, chromium, manganese, and nickel; and mercury was not present above the DL of 100 ppm. However, the Niton XRF was unable to provide information about cadmium or beryllium, as these elements were not detectable due to interference by the XRF's cadmium source.

*Stripping*

XRF readings revealed no detectable levels of lead (detection level of 0.05 mg/cm$^2$) on the steel that had been stripped (mean of $<0.07 \pm 0.02$ mg/cm$^2$ for 23 readings of stripped areas). These low readings indicate that the stripping method, open abrasive blasting, was effective in removing paint.

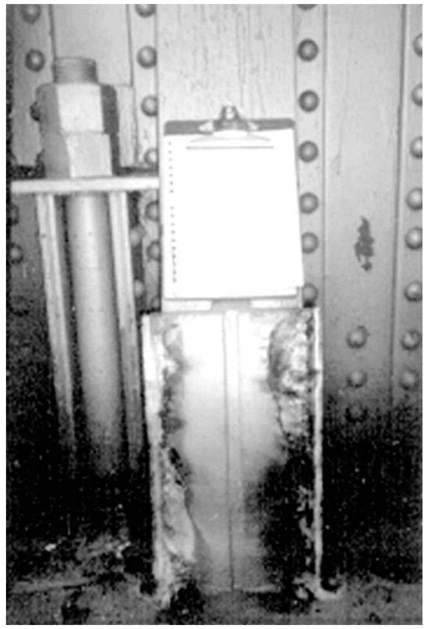

**FIGURE 2**
Burnt lead paint illustrates inadequate stripping.

Field measurements using a tape measure of 12 of the cuts revealed that the paint was stripped back an average of 1.15 (range of 0.5 to 4.0 inches) inches from the cut line (based on 69 measurements taken). After hot cutting, burned paint provided visual evidence that stripping was insufficient (Figure 2).

Visual observation and XRF measurements confirmed that eight of the 40 segments to be cut (the inside corner pieces) had not been stripped at all, since the XRF readings were no different from readings taken in the painted areas. The XRF was needed to confirm lack of stripping since new primer paint had been applied, making it difficult to visually determine which areas had been stripped.

*Personal Sampling Results*

The eight-hour TWA lead exposure for day one was 3898 $\mu$g/M$^3$, or 78 times the OSHA Permissible Exposure Limit (PEL) of 50 $\mu$g/M$^3$. The task-specific exposure level during hot cutting on day one was 11,271 $\mu$g/M$^3$ (166-minute TWA); this involved cutting on both stripped and unstripped steel. The eight-hour TWA lead exposure on day two was 4027 $\mu$g/M$^3$ (81 times the PEL). The task-specific exposure level when working on the stripped steel was 670 $\mu$g/M$^3$ (91-minute TWA). In contrast, the exposure level when working on the unstripped steel in the corners was 30,000 $\mu$g/M$^3$ (63-minute TWA) (Table I).

*Personal Protection Observations*

The ironworker was wearing a half-mask, air-purifying respirator with "pancake" style P-100 filters, welder's helmet, foam earplugs, and heavy welder's

**TABLE I**
Personal air sampling lead results for ironworker

| Date | Activity | Sample time (minutes) | Results ($\mu$g/M$^3$) | 8-hr TWA ($\mu$g/M$^3$) |
|---|---|---|---|---|
| Day one | OSHA full-shift sampling | | | |
| | Carbon are cutting of 3/4-inch steel | 166 | 11,271 | 3898 |
| Day two | Oxygen/propane torch cutting of 3/4-inch steel | 154 | 12,552 | 4027 |
| | Task-specific sampling | | | |
| | Cutting of stripped steel | 91 | 670 | |
| | Cutting of unstripped corner pieces | 63 | 30,000 | |

gloves (Figure 1). At the end of day two, small holes were found in the P-100 respirator pancake filters, apparently due to welding sparks. The filter material at the inhalation valve gasket was discolored on one of the filters. These holes and the discoloration indicated at least partial failure of the filter.

## Discussion

### *Air Sampling Results*

This was a very limited industrial hygiene survey in which a single ironworker was monitored over two successive days of hot cutting on stripped steel. However, the survey illustrates that several factors may contribute to high lead exposures experienced by ironworkers. First, the so-called stripped areas may be stripped back significantly less than the Cal/OSHA required four inches on both sides of a cut line. Second, difficult-to-reach corners may not be stripped at all. If these results are typical of exposures to ironworkers working on bridges, then minimum respiratory protection should be half-mask, supplied-air respirators in positive-pressure mode, as initially required by the Lead in Construction Standard for highest exposure trigger tasks.

The results of short-term lead exposure monitoring during hot cutting on stripped and nonstripped areas indicate that hot work on .75-inch steel which has been stripped back only 1.15 inches from the cut line creates significantly less exposure than work on unstripped steel (670 $\mu$g/M$^3$ vs. 30,000 $\mu$g/M$^3$). However, cutting of the stripped areas results in exposure levels that exceed the maximum use concentration (MUC) of the half-mask respirator that this ironworker was wearing (MUC = 10 × PEL), if sustained over an eight-hour shift. Further studies are indicated to determine whether hot work on steel that is stripped back the required minimum of four inches reduces exposure to airborne levels less than the PEL.

### *XRF Results*

The XRF was a useful tool for determining which areas were adequately stripped and which were not. Visual observation, on the other hand, would have been inadequate in locating the unstripped corner areas identified by the XRF, since these areas had been newly primed with the same gray primer (non lead-based) as the stripped areas. The XRF also detected that the lead was located primarily in the deepest (red-colored) original paint layers.

The XRF was somewhat useful as a gross qualitative tool in determining which elements were present besides lead (iron and zinc) and which elements were below its detection limit (arsenic, chromium, manganese, and nickel below a DL of 500 ppm; mercury below a DL of 100 ppm). Laboratory results for arsenic (<50 ppm) concurred with the XRF readings (<500 ppm). However, the laboratory analysis for chromium (1900 ppm) did not agree with the XRF reading (<500 ppm). This discrepancy casts some doubt on the usefulness of the XRF as a metals-screening tool. In addition, cadmium and beryllium could not be measured with this model XRF due to the interference from the cadmium radiation source.

### *Respiratory Protection Inadequacies*

Hot work on bridges is often viewed incorrectly as a low-lead or nonlead activity, since industrial painters have supposedly stripped back the steel before the ironworkers arrive. In this instance, the ironworker had only a half-mask, air-purifying respirator available. Ironworkers performing hot work on structures with high concentrations of lead in the paint should be required to wear air-supplied respirators in positive-pressure mode initially. Moreover, sparks may burn holes in respirator filters, reducing their effectiveness.

### *Multi-Employer Challenges*

Lead exposure issues are magnified at a multi-employer worksite consisting of many layers; in this case, the state department of transportation, general contractor, painting subcontractor, and ironworker subcontractor. First, the government agency responsible for bridge repair may be reluctant to play a strong role in worker safety, fearing that intervening in contractor affairs makes them liable in the case of a third-party injury suit. Second, the general contractor, with overall responsibility for safety and health conditions at the worksite, may shortchange safety in the interest of production. Finally, the ironworker, arriving on the site after the painters have left, may discover that the stripping is inadequate, but decide to complete the job anyway. Further, the ironworker may be an owner or operator, as in this survey, and may not be covered by OSHA regulations.

### *Safe Practices Recommendations*

The following measures should be enforced by bridge or building owners and general contractors to prevent overexposures during hot work:

- Strip lead paint a *minimum* of 4 inches on both sides of the cut or weld line
- Improve quality control to ensure that all areas, including difficult-to-reach corners, meet specifications for stripping before allowing hot work to begin.
- Require ironworkers performing hot work to wear air-supplied respirators in positive-pressure mode. Downgrade respiratory protection if: (a) visual inspection (or XRF measurements) indicate that the amount and quality of paint stripping is consistent, and (b) representative air sampling results indicate that less respiratory protection is sufficient.
- Ensure that all lead-exposed trades understand and follow the requirements of the Lead in Construction Standard.
- Ensure that ironworkers receive regular and frequent blood lead testing.

### *Research Needs*

This survey indicates that ironworkers performing hot cutting on bridges or other steel structures may encounter very high lead exposure levels due to inadequate paint stripping. Further research is needed to determine how frequently these overexposures occur, whether the four-inch-minimum stripping requirement is adequate to ensure airborne lead levels below the PEL, and what types of multi-employer policies will prevent such exposures.

## REFERENCES

1. Code of Federal Regulations, 29 CFR 1926.354: Welding, Cutting and Heating in Way of Preservative Coatings. U.S. Government Printing Office, Office of the Federal Register, Washington, DC (1966).
2. California Code of Regulations, 8 CCR 1537: Welding, Cutting, and Heating of Coated Metals (1975).
3. Holness, D.L.; Nethercott, J.R.: Acute Lead Intoxication in a Group of Demolition Workers. Appl Ind Hyg 3:338–341 (1988).
4. Goldberg, M.; Clark, N.L.; Levin, S.M.; et al.: An Assessment of Lead Controls for Torch Cutting and Rivet Removal on Steel Structures. Appl Occup Environ Hyg 15:445–452 (2000).
5. Olhiser, B.: Personal communication to the author on January 25, 2000.

**EDITORIAL NOTE:** Simone Brumis, Peter Scholz, and Barbara Materna are with the California Department of Health Services, Occupational Lead Poisoning Prevention Program, Oakland, California. They may be contacted by phone at (510) 622-4300 or by e-mail sbrumis@dhs.ca.gov.